

SINFONI Observations of Starclusters in Starburst Galaxies

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Abstract

We have used ESO's new NIR IFS SINFONI during its Science Verification period to observe the central regions of local starburst galaxies. Being Science Verification observations, the aim was two-fold: to demonstrate SINFONI's capabilities while obtaining information on the nature of starclusters in starburst galaxies. The targets chosen include a number of the brighter clusters in NGC1808 and NGC253. Here we present first results.

Key words: galaxies: individual (NGC 253, NGC 1808); galaxies: starburst;

galaxies: star clusters; infrared: galaxies

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1 Introduction

That star formation in starburst galaxies manifests itself in the production of numerous young, massive, clusters or super-starclusters is by now observationally quite well established (e.g. (8); (7) and references therein; (2)). At least in part owing to the strong, patchy obscuration in these systems the nature of these clusters is less well known, especially with respect to their age, mass, boundedness and the likelihood of their survival (but see, for example, (7) and (3)). We have made short observations of near- and circumi-nuclear fields in two nearby starburst galaxies, NGC 253 and NGC 1808, during SINFONI Science Verification. We are using these data to better characterize the central starburst regions and starclusters in these systems. Here we present a brief summary of initial results.

¹ On behalf of the SINFONI Science Verification Starburst Team

2 SINFONI and Observation Overview

SINFONI, offered to the community since 01 Apr. 2005, is a combination of a NIR Integral Field Spectrometer (SPIFFI) and a MACAO adaptive optics module. Briefly, SPIFFI, uses gratings to provide the user with data with a spectral resolution of 2000, 3000, 4000 (in the J, H, and K Bands, respectively), or 1500 for the combined H+K Bands. The spatial sampling of 64×32 pixels over square fields-of-view $0.8''$, $3''$, or $8''$ on a side is achieved by slicing the field with a mirror-pair image slicer and imaging it onto a Hawaii 2RG detector. The largest of these fields-of-view is meant primarily seeing-limited operation, as is the case in the absence of a suitable adaptive optics reference target.

The MACAO unit is very broadband in its response, though is peaked in the R Band. Although targets with R magnitudes less than about 11 yield the best corrections, some correction can be achieved to $R \sim 17$ under the best conditions. In very good conditions moderate improvement can be achieved even to $30''$ separation between the AO-target and the science target².

The observations reported on here were made with the H+K grating and the $0.8''$ (NGC 253; two fields with 200 and 480 sec exposures) and $0.8''$ (NGC 1808; two fields with 10 and 20 min exposures) pixel scales. The NGC 1808 observations used the MACAO unit, while the NGC 253 observations were done in seeing-limited mode.

3 First Results

3.1 $Br\gamma$ and HeI in NGC 253

In Figure 1 we present images of the log of the $Br\gamma$ emission (left), the log of the equivalent width of $Br\gamma$ (center), and the ratio of the $2.058 \mu\text{m}$ $2^1\text{P}-2^1\text{S}$ HeI line to $Br\gamma$ (right) in the circumnuclear region of NGC 253. The $Br\gamma$ is seen to peak strongly at the position of the well-known IR peak in this galaxy to the SW on the nucleus, consistent with what is seen in $\text{Pa}\alpha$, $\text{Br}\delta$, and $2.058 \mu\text{m}$ $2^1\text{P}-2^1\text{S}$ HeI (not shown).

Although the $2.058 \mu\text{m}$ $2^1\text{P}-2^1\text{S}$ HeI line is not an ideal tracer of the hardness of the radiation field ((5),(6)), its ratio with $Br\gamma$ and the $\text{EW}_{Br\gamma}$ in the two peaks shown in Figure 1 (right) are consistent with starburst age of 5.5 Myr with

² Further details for SINFONI can be found on the ESO SINFONI webpage, <http://www.eso.org/instruments/sinfoni/index.html>, and on pages linked to from that page.

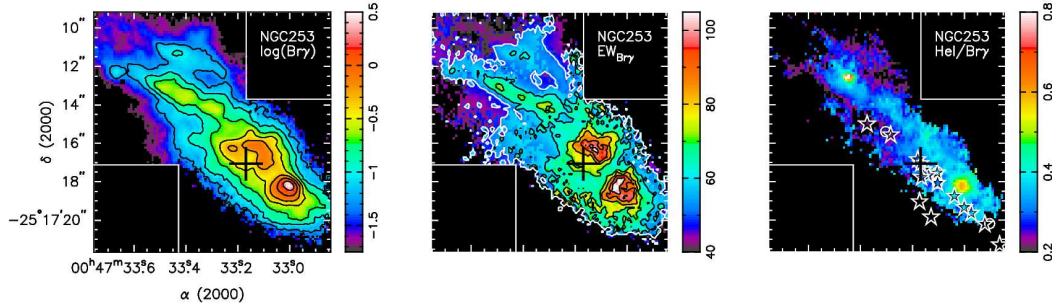


Fig. 1. Images of the circumnuclear region of NGC 253 as described in the text. In each panel the black $+$ indicates the position of the nucleus, and the white lines indicate the limits of the observed mosaic. In the right panel circles indicate ultracompact HII regions from (4), stars are 2 cm radio continuum sources from (10); see (8) for details.

the most massive stars being $\sim 30 M_{\odot}$. This is less massive than postulated by some authors for the bright peak to the SW of the nucleus, but the resulting radiation field is likely consistent with what would be required to explain the strong decrease in the $3.3 \mu\text{m}$ PAH feature-to-continuum ratio at these positions (9). Observations of a “pure” line³ of HeI, such as the $1.7007 \mu\text{m}$ $4^3\text{D}-3^3\text{P}$ line (5), would be useful to properly constrain this scenario.

3.2 A Comparison with HST NICMOS

As a means of demonstrating the combined capabilities afforded by both the VLT-UT4 and SINFONI itself, we present in Figure 2 an image of the $1.644 \mu\text{m}$ [FeII] line emission from NGC 253 as observed with SINFONI. This region has been previously observed in the same line with *HST* NICMOS (1), and the contours in Figure 2 are derived from that data. The correspondence is quite remarkable indeed, especially considering that the SINFONI data are seeing-limited. However, the true advantage of SINFONI over *HST* NICMOS lies in the wealth of information afforded by the IFS itself (through velocity (dispersion) maps, not shown here due to space limitations).

3.3 Star clusters in NGC 1808

The data from our AO-assisted observations of two clusters in NGC 1808 are a bit noisier than those of NGC 253, which compromises (at least thus far) our ability to construct fruitful line maps. However, in Figure 3 we present collapsed K-Band images of the fields observed, with each of the two right

³ One for which the line strength is determined almost solely from the recombination cascade physics.

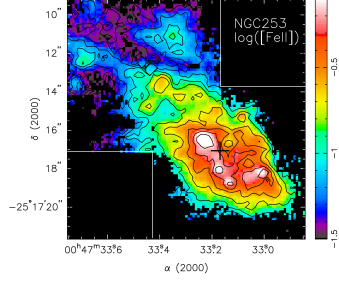


Fig. 2. An image of the $1.644\,\mu\text{m}$ [FeII] emission in the circumnuclear region of NGC 253 observed with SINFONI on the VLT-UT4. Markings are as in Figure 1. *The overlaid contours are derived from the HST NICMOS observations of (1).*

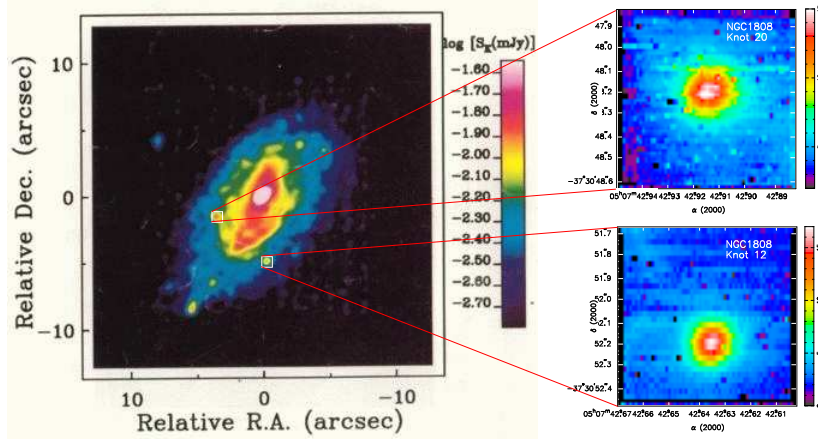


Fig. 3. (left) K-Band speckle image of the circumnuclear region of NGC 1808 (8) illustrating the SSC knots, (right) preliminary reductions of SINFONI observations of two of the clusters represented as data cubes collapsed into K-Band images.

panels being $0.8''$ on a side. We have used our best guess at the PSF (from the telluric calibration star) and infer an upper limit on the size of these clusters of 15 pc and 8 pc for Knots 20 and 12 (Figure 3 top right, and bottom right), respectively. This is broadly consistent with the sizes quoted in (8).

References

- [1] Alonso-Herrero, A. et al., 2003, *AJ*, **125**, 1210
- [2] de Grijs, R., this volume
- [3] Gieles, M. et al., 2005, *astro-ph/0506066*
- [4] Johnson, K.E. et al., 2001, *ApJ*, **559**, 864
- [5] Lumsden, S.L., Puxley, P.J., and Hoare, M.G., *MNRAS*, **320**, 83
- [6] Rigby, J.R. and Rieke, G.H., 2004, *ApJ*, **606**, 237
- [7] Mengel, S., et al., 2005, *astro-ph/0505445*
- [8] Tacconi-Garman, L.E., Sternberg, A., and Eckart, 1996, *AJ*, **112**, 918
- [9] Tacconi-Garman, L.E. et al., 2005, *A&A*, **432**, 91
- [10] Ulvestad, J.S. and Antonucci, R.R.J. 1997, *ApJ*, **488**, 621